How do our 'Quicks' Generate Pace? A Cross Sectional Analysis of the Cricket Australia Pace Pathway

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Technique and physical contributions to ball delivery speed in fast bowling have been popular research topics in sports science. However, a common limiting factor of this work is the level of expertise of participants and lack of within-bowler investigations (Salter et al., 2007). The relationship between technique, anthropometry and ball speed has not been comprehensively investigated among elite fast bowlers. The purpose of this study was to examine the relationship between technique, anthropometric variables and ball speed using both within- and between-bowler analyses in a cross section of the Cricket Australia high performance pace pathway.

Thirty, Australian nationally-contracted (NAT, n = 8, age 29.1 + 3.2 yrs), centre of excellence and emerging (EMG, n = 11, age 20.8 + 3.1 yrs) and junior pace squad (JNR, n = 11, age 17.4 + 0.6 yrs), fast bowlers performed 30 trials of good, short and full length deliveries at match intensity. Bowling action and coordination were measured from three-dimensional full body movement data captured using a 22-camera VICON motion analysis system (Oxford Metrics Ltd., Oxford, UK) sampling at 250 Hz. The University of Western Australia cluster-based model was used to calculate three-dimensional joint kinematic measures (Lloyd et al., 2000). Full body global and relative joint angles were measured using the conventions outlined in Portus et al. (2004). Ground reaction force (GRF) for back foot contact (BFC) and front foot contacts (FFC) were collected at 1000 Hz (Kistler, Amherst, USA). Anthropometric measures were taken (skin folds, girths, and breadths) following the protocols used by Pyne et al. (2006). A one way analysis of variance with post hoc Scheffé tests was used to determine any differences in anthropometrics between the groups. Pearson's product moment correlation coefficients (r) were calculated to establish the relationship between selected anthropometric, kinematic, temporal and kinetic parameters and ball release speed both within individual fast bowlers and between skill groups (significance set at $p < 0.05$). Correlations were classified in accordance with Hopkins et al. (2000) as follows: r<0.01 trivial, small 0.1 – 0.3, moderate 0-3 – 0.5, large 0.5 - 0.7, very large 0.7 – 0.9, nearly perfect > 0.9.

Table 1: Comparison of selected anthropometrics and correlations to ball speed (*r*).

	JNR		EMG		NAT		Anova
	Mean ± s	*r*	Mean ± s	*r*	Mean ± s	*r*	*p* value
Height (cm)	188.5 ± 3.4	-0.30	190.6 ± 6.4	-0.45	188.9 ± 7.7	-0.42	0.68
Body mass (kg)	83.4 ± 5.2	0.37	89.5 ± 8.2	-0.33	92.1 ± 5.3	-0.38	0.01*[b]
% Muscle mass (BW)	45.7 ± 1.4	0.31	46.2 ± 1.8	-0.26	46.6 ± 1.4	-0.34	0.01*[a,b]
% Fat mass (BW)	9.2 ± 1.1	0.13	9.9 ± 2.8	-0.25	9.4 ± 1.8	-0.73[+]	0.67
Humerus breadth (cm)	7.3 ± 0.3	0.62[+]	7.4 ± 0.4	-0.49	7.4 ± 0.2	-0.27	0.77
Gluteal girth (cm)	57.4 ± 3.2	0.41	60.4 ± 3.2	-0.10	62.5 ± 2.2	-0.33	0.00*[b]
Chest depth (cm)	18.7 ± 2.1	0.60[+]	20.9 ± 1.4	0.17	22.0 ± 1.6	-0.46	0.00*[a,b]
Ball Speed (km/h)	120.0 ± 3.9	-	123.1 ± 2.5	-	125.6 ± 6.7	-	0.01 *[b]

* Post hoc comparisons: significant difference (p<0.05) between JNR - EMG[a], JNR - NAT[b], and EMG - NAT[c].
[+] Significant correlations to ball speed (p<0.05)

Anthropometric Differences and Correlations to Ball Speed: There was no significant difference in height between groups. The greatest number of statistically significant differences existed between the NAT and JNR groups. The NAT group had significantly greater body mass, % muscle mass, gluteal girth, chest depth and bi-acromial distance compared with the JNR group (Table 1). The EMG group also had significantly greater % muscle mass and chest depth and bi-acromial distance compared with the JNR group.

Table 2: Group Mean data(s) and Pearson's product moment correlation coefficients (*r*) between selected kinematic, temporal and kinetic parameters and ball release speed.

	JNR		EMG		NAT	
	Mean ± s	*r*	Mean ± s	*r*	Mean ± s	*r*
Kinematics (°)						
BFC Shoulder alignment	-36.8 ± 15.7	-0.20*	-32.2 ± 11.7	-0.37*	-33.4 ± 10.7	0.32*
Pelvis alignment	-55.3 ± 11.5	0.40*	-54.8 ± 10.3	0.10	-55.8 ± 6.1	0.40*
Trunk flexion angle	-1.6 ± 8.5	-0.25*	-5.9 ± 9.9	-0.37*	-5.7 ± 9.9	-0.09
Hip shoulder sep	12.6 ± 18.7	0.17*	19.9 ± 16.4	-0.18*	9.8 ± 19.7	-0.14*
Back knee flexion	44.0 ± 12.2	0.40*	38.6 ± 11.9	-0.14*	40.8 ± 14.3	0.30*
FFC Trunk lateral flexion	-16.5 ± 5.8	-0.16*	-15.3 ± 8.4	0.40*	-14.7 ± 8.2	0.06
Front knee flexion	9.8 ± 9.4	-0.12*	5.4 ± 7.1	0.11	11.0 ± 8.2	-0.42*
BR Trunk lateral flex	-26.6 ± 6.6	0.43*	-26.0 ± 7.0	0.03	-31.6 ± 4.3	0.33*
Shoulder CR	40.9 ± 13.2	-0.30*	40.2 ± 11.6	0.15*	39.6 ± 11.8	0.30*
Max Front Knee flexion	39.4 ± 20.2	-0.16*	22.3 ± 17.8	-0.13*	38.6 ± 12.1	-0.50*
Back Knee flexion	69.7 ± 7.7	0.28*	66.3 ± 9.5	0.11	74.4 ± 11.9	0.47*
RoM Trunk lat flex	22.3 ± 29.0	0.23*	31.7 ± 32.4	-0.21*	22.2 ± 38.3	-0.33*
(BFC–BR) Trunk flexion	50.8 ± 7.6	0.55*	52.4 ± 10.1	0.17*	45.5 ± 9.0	-0.20*
Hip-shoulder sep	71.3 ± 19.4	0.29*	76.9 ± 15.3	-0.16	74.7 ± 11.9	0.30*
Max Vel Non B Arm (°/s)	742.7 ± 107.9	0.08	787.7 ± 185.6	0.27*	779.24 ± 159.9	0.45*
Run-up Speed Ave (m/s)	5.3 ± 0.4	0.42*	5.4 ± 0.4	-0.07	5.3 ± 0.5	0.34*
Ave last 5m	5.8 ± 0.4	0.50*	5.8 ± 0.4	-0.17*	5.7 ± 0.4	0.52*
Max	6.6 ± 0.4	0.38*	6.5 ± 0.4	-0.24	6.5 ± 0.5	0.54*
Time duration BFC- BR	0.28 ± 0.03	-0.18*	0.31 ± 0.03	0.19*	0.31 ± 0.05	0.04
Kinetics (body weight)						
FFC Max Vertical Force	6.1 ± 1.6	0.30*	6.3 ± 1.3	0.04	7.5 ± 1.3	0.34*
Max Braking Force	4.0 ± 1.1	0.34*	4.1 ± 0.9	0.43*	4.5 ± 0.9	0.75*
BFC Max Vertical Force	2.2 ± 0.5	0.25*	2.9 ± 0.9	0.09	2.7 ± 0.6	0.47
Max Braking Force	1.2 ± 0.6	0.01	1.7 ± 0.7	0.01	1.4 ± 0.4	0.20*

(global pelvis orientation, 0° = front on, -90° = side on; knee angle, 0° = full extension, 90° = flexion)
*Significant correlation (p<0.05)

The NAT group produced significantly higher ball speeds than the JNR group (125.6 km/h ± 6.7 v 120.0 km/h ± 3.9, p = 0.03). These data were similar to the EMG group (123.1 ± 2.5). Several large correlations were found between anthropometric variables and ball speed in the JNR and NAT groups. Faster ball speed was associated with greater humerus breadth, and chest depth in the

JNR group. Conversely, in the NAT group faster ball speed was related to less fat mass (as a percentage of body mass). No statistically significant correlations between anthropometrics and ball speed were found in the EMG group.

Technique Differences and Correlations to Ball Speed: In the between-bowler group analysis several moderate and large correlations were found between technique variables and ball speed within all groups. In the JNR group increased ball speed was associated with a faster run up, especially in the last 5 m and a more side-on action at BFC with their knee more flexed. From this position, faster JNR bowlers increased the level of trunk flexion up to BR and had their trunk more laterally bent at BR. Faster ball speed in EMG bowlers was correlated with greater lateral trunk flexion at FFC and higher front foot braking forces. In the NAT group greater ball speed was associated with being more side on at FFC, more flexion in the back leg, faster non-bowling arm pull down and higher front foot braking forces. Faster run-ups and less knee collapse at FFC were also related to faster deliveries.

Within-bowler analysis, where each bowler's movement solutions are studied separately across all 30 deliveries bowled, showed that run-up speed and knee flexion angle remained related to bowling faster. Across most variables individual analysis supported group correlations, although it was able to identify outliers within groups. Inconsistencies in technique factors related to increased ball speed across bowlers can be explained by difference in technique. For example, bowlers' front knee flexion – extension could be separated into those that extended and those that flexed the knee between FFC and Ball release within groups (Figure 1.), likely having different effects on ball speed.

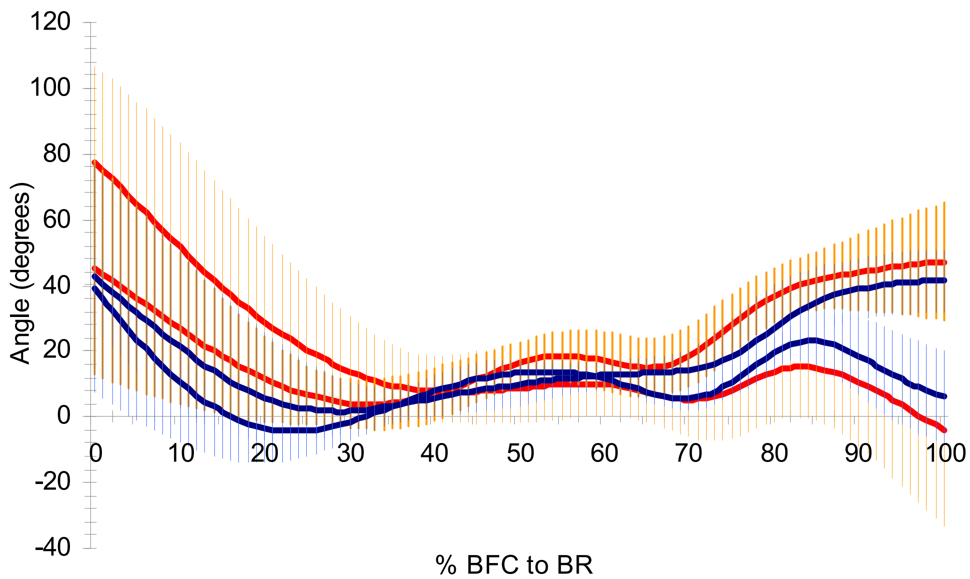

Figure 1: NAT (blue) and JNR (red) Mean(s) front knee flexion-extension angle separated into FFC flexion and extensions groups. (0^{O} = full knee extension)

Conclusions: Factors related to JNR and EMG bowlers creating ball speed were not the same as those for NAT bowlers. To produce greater ball speed National team bowlers maintained a strong front leg at FFC and hand faster non-bowling arm pull down, while there was only a small relationship between the same variables in the JNR and EMG groups. Across all groups, greater ball speed was associated with higher FFC max braking force, the strength of this correlation increased will skill level. Bowling squads varied in anthropometrics, however generally, technique factors were more strongly related to ball speed than physical characteristics. Within-bowler analyses revealed unique movement solutions for generating ball speed in some individuals adding to the value of using within-group methodologies in biomechanics and motor control research.

Acknowledgements: The authors would like to acknowledge Cricket Australia funding and Wayne Spratford, David Pyne, Carl Petersen and AIS Biomechanics scholars for their assistance with data collection.

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